Very Long Wavelength Universe: view from the Moon

L.I .Gurvits (1), H. Falcke (2,3), Y. Yan (4) and M. Huang (4)

(1) Joint Institute for VLBI in Europe, Dwingeloo, The Netherlands, (2) ASTRON, Netherlands Foundation for Research in Astronomy, Dwingeloo, The Netherlands, (3) Department of Astrophysics, Radboud University, Nijmegen, The Netherlands, (4) National Astronomical Observatories, Chinese Academy of Sciennces, Beijing, China (lgurvits@jive.nl / Fax: +31 521 597332)

Moon is an inevitable destination in the exploration Space by mankind. The use of lunar bases as scientific laboratories is among the most attractive opportunities for the early stages of the exploration of the Moon. Environmental conditions on the Moon are beneficial for various types of experimental research. Very Long Wavelength radio astronomy is among the most attractive scientific disciplines for the suit of Moon-based laboratories.

During the last half a century, space science has revolutionised astronomy by opening up several hitherto inaccessible windows in the spectrum. The opening of each new spectral window has resulted in unexpected major discoveries and made it possible to obtain a comprehensive picture of physical processes in celestial sources by observing their emission in the entire EM-spectrum. One of the last remaining unexplored regions of the spectrum is at the lowest radio frequencies. Radio emission below 15 MHz (wavelengths longer than 20 m) is inaccessible from the ground due to ionospheric absorption and scattering. Anthropogenic radio interference is also a very serious limiting factor for studying the Universe at wavelengths longer than 20 m.

The VLW radio region probes unique physical phenomena in the Universe:

- The radiation mechanism that dominates radio astronomy at frequencies above about 50 MHz is synchrotron emission, with extragalactic and galactic sources of radiation dominating the radio sky. At lower frequencies other mechanisms such as plasma oscillations produce coherent radiation, and the brightest objects in the sky are the Sun and Jupiter. Surveys of the sky at frequencies of 5 MHz and below are likely to reveal classes of new objects, including the possibility for a direct detection of extraterrestrial planets.

- VLW astronomy probes synchrotron emission produced by relativistic electrons that are almost as old as the age of the Universe ($\sim$3 x 10^9 years at 1 MHz), thereby providing fossil information that has been relatively unaltered by evolution.

- Ultra-high-energy cosmic rays and neutrons bombarding the Moon surface produce coherent VLW emission, making them readily detectable.

Exciting unique new science areas for VLW radio studies include:

- Solar system “weather”, including coronal mass ejections,
- Searches for Jupiter-like exoplanets,
- Investigating sources of coherent radiation.

In addition to the astrophysical tasks mentioned above, the VLW mission on the Moon can be realized as a Wide Area Network, as pioneered by ground-based Low Frequency Array (LOFAR). This allows the inclusion of other sensors, such as seismic detectors to conduct selenological studies. The LOFAR is being constructed in the Netherlands. It will operate in the frequency range 20 - 220 MHz. The Chinese-led project PAST (currently under construction in Western China) will aim at addressing cosmological problems by studying the Universe at the range of frequencies below 100 MHz. These and other new radio astronomy facilities and will lay the scientific and technological ground for VLW astronomy in space.

We will present a multi-step approach toward creating a permanent VLW observatory on the Moon. Its first phase would include a demonstrator to be deployed as a small-scale scientific payload onboard one of the lunar missions of the next decade. A concept of an affordable full-scale observatory will be presented in the context of a long-term exploration programme of the Moon.